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1959 GREEN-FUEL MOISTURE AND SOIL MOISTURE TRENDS IN SOUTHERN CALIFORNIA

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One of the major problems confronting fire control forces is that of rating the flammability of various plant covers. There is no commonly accepted definition, or test for, fire resistance that can be applied to wild fire situations. Susceptibility to fire cannot be rated solely by plant species. It is not the species of plants on an area that determines fire potential, but the amount, arrangement, and moisture content of this vegetation. Part of the Fuel-Break 1/ research program is aimed toward the solution of this problem.

Green-fuel moisture content is a measure of the amount of water in parts of living plants normally consumed by fire. It is a useful fuel flammability factor to know because: (1) up to 50 percent of the heat energy released may come from the green fuel (Anonymous, 1955a), and (2) of all fuel factors, moisture content probably has the greatest effect on fire behavior. Knowledge of this factor is needed not only in fire danger rating but also as a possible clue to finding a "fire resistant" plant.

1/ FUEL-BREAK--aimed at breaking up continuous brush fields for better management and fire control, is a joint research, pilot-plant, and administrative action program of the California State Division of Forestry, Los Angeles County Fire Department, and the U. S. Forest Service.

Several workers have studied the variations which occur in green-fuel moisture and described their significance (Anonymous, 1955 b; Buck, 1938 2/; Fons, 1943 3/; and Richards, 1940). But little is known about the relationship between the weather and the moisture content of living fuel. This paper reports the first results from a plot set up in 1959 to make long-term simultaneous measurements of these variables.

STUDY AREA AND METHODS

The plot is located in Bell Canyon, San Dimas Experimental Forest 4/, at 3,100 feet elevation. This area was selected because it is representative of south slopes in the chamise-chaparral vegetation--the most critical fuel type in southern California. The climate is described as typically Mediterranean (Hamilton, 1951). In the preceding 25 years at nearby Tanbark Flat (2,725 feet elevation) annual precipitation ranged from 11.47 to 48.23 inches, with a mean of 28.27(Reimann and Hamilton, 1959). In 1958-59 precipitation was 14.34 inches at Tanbark Flat and 14.88 inches at the Bell Canyon plot.

Samples of leaves and stems less than 1/8-inch in diameter were collected weekly, from three samples of 5 to 10 plants each for each of the three species. Old and new growth portions of plants were lumped in each sample. Species sampled were chamise (*Adenostoma fasciculatum*), hoaryleaf ceanothus (*Ceanothus crassifolius*), and black sage (*Salvia mellifera*). Moisture contents (percent dry weight) were obtained by xylene distillation (Buck and Hughes, 1939). Soil moisture (percent by volume) for various depths of soil was determined weekly with Colman electrical resistance units (Colman and Hendrix, 1949) in an unconfined lysimeter at Tanbark Flat, as part of the watershed research program.

Relative humidity, temperature, wind speed and direction, and moisture percent of 1/2-inch fuel moisture sticks were also measured and recorded. This report, however, considers only the analysis of soil moisture, green-fuel moisture, and precipitation variables. Other weather elements will be included in later analyses.

2/ Buck, C. C. Progress report on variations in the moisture content of green brush foliage on the Shasta Experimental Forest during 1937, U. S. Forest Serv. Calif. Forest and Range Expt. Sta. 1938. Unpub. MS.

3/ Fons, W. L. Progress report on seasonal variation in moisture content of chaparral foliage on the San Dimas Experimental Forest during 1942. U. S. Forest Serv. Calif. Forest and Range Expt. Sta. 1943. Unpub. MS.

4/ The San Dimas Experimental Forest is a field unit of the Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, maintained in cooperation with the State of California Division of Forestry.

RESULTS

Because 1959 was an extremely dry year, the fuel moistures recorded this year represent data for plants under drought stress. The data cannot be considered typical of a normal year, but by the same token the trends are of particular importance to fire-control specialists.

The trends for the three species (fig. 1) showed that:

1. The species differed a good deal in moisture content from January to July, but were similar from July to December.

2. In all three species, moisture content built up in winter and spring and declined in summer. Rates of increase and decrease were not identical, but the changes occurred at about the same time in all species.

3. The decline in moisture content began early in June.

4. The major decline in moisture content ended in early September.

5. Thereafter, the green-fuel moisture remained at a low level until mid-December. Possibly, this level may be the lowest moisture content at which the plants can remain alive. Buck (1951) has pointed out that whole plants or parts of plants may die under extended drought, increasing the ratio of dead fuel to living fuel.

Similar trends of moisture were recorded during Operation Firestop (Anonymous, 1955a) and during 1942 sampling of chaparral foliage at the San Dimas Experimental Forest 5/.

Precipitation and soil moisture records showed (fig. 2) that:

1. Soil moisture was rather low all year. Most of the precipitation was either evaporated or transpired before it reached deep soil, and therefore little water went into storage for use later in the season.

2. By late August, soil moisture at all depths had reached the permanent wilting point, where it remained until a storm December 9.

3. The top layer of soil gained moisture rapidly during storms but then lost the moisture rapidly.

5/ Fons, W. L. 1943. op. cit.

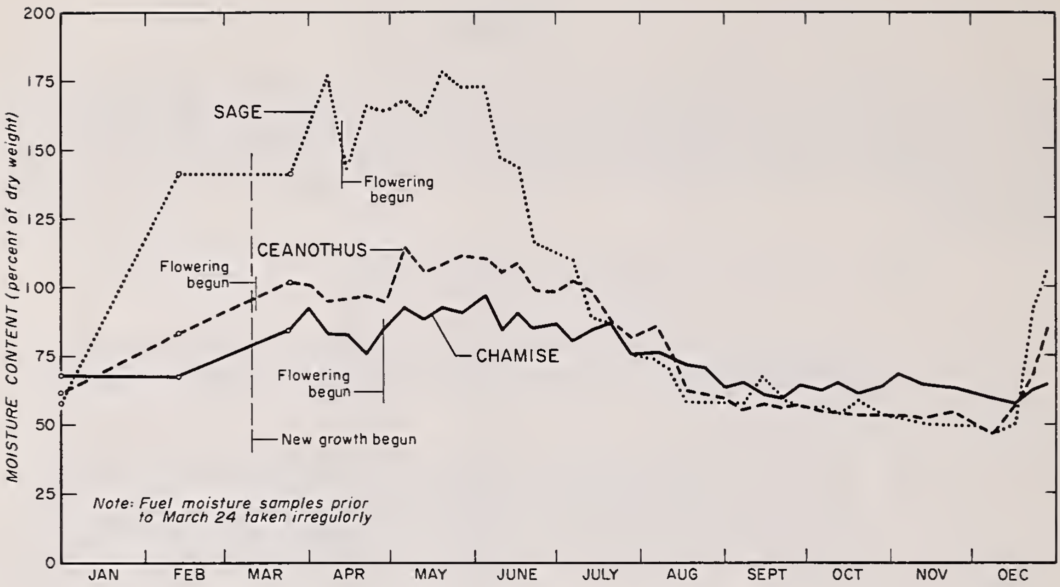

Figure 1.--Green-fuel moisture content, in percent of dry weight, of foliage and small stems, for three chaparral species, 1959.

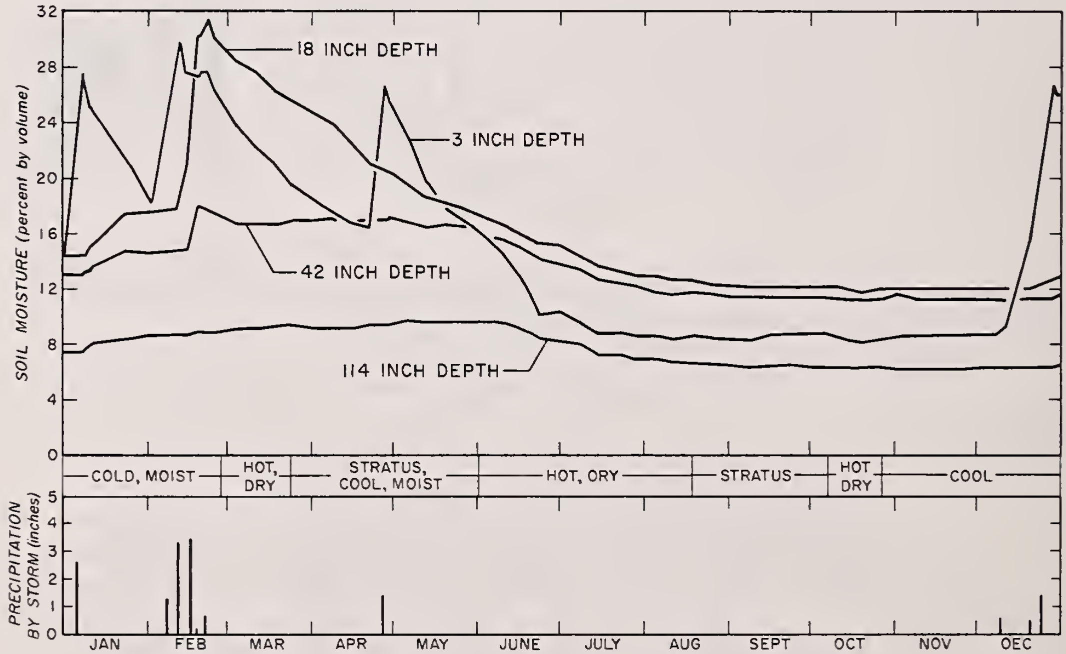

Figure 2.--Rainfall and soil moisture at lysimeter B, (unconfined chamise, 1959).

4. At greater depths the soil moisture response was slow and lagged behind the storms.

An explanation for the difference in response may be that at shallower depths soil moisture was depleted at a rate governed primarily by evaporation; at greater depths, at a rate dependent upon transpiration.

Trends of soil moisture and green-fuel moisture were much alike (figs. 3, 4, and 5). Probably, the moisture content of chaparral plants at this site is dependent on available soil moisture. Moisture available to roots is used for growth and is contained in the vascular system. But when soil moisture falls off, the plant tissue dries; the plant may go into dormancy, and green-fuel moisture remains at a minimal content, when the soil is at or near the wilting point.

Ceanothus moisture content reached 114 percent, its highest point in 1959, by May 5 and then began to decline (fig. 3). Soil moisture at 42-inch depth began to decrease from the 17 percent level in the last week of April. Both green-fuel moisture and 42-inch soil moisture were near their low points by mid-August.

An earlier study (Anonymous, 1955b) had reported ". . . no short term fluctuations in moisture content of either new or old growth which can be attributed to the recency or amount of rainfall." In the present study the rainfall of 1.5 inches on April 26 penetrated 6 to 12 inches into the soil. Green-fuel moisture rose from 94 percent to 114 percent. Apparently roots near the surface were able to use the added moisture. Rainfall distribution may explain the difference between the results of the two studies. Rains occurred after the plants were dormant in the earlier study, but during the growth period in 1959. Then too, because available moisture was limited in 1959, the April rainfall may have had more effect than if soil moisture had been normal after a winter of normal rainfall. Data from following years will check this possibility. Ceanothus green-fuel moisture also responded quickly after December rains. Although little or no water reached the 42-inch soil depth, moisture content of living fuel jumped from 47 percent to 85 percent in response to 2.5 inches of rainfall.

Black sage picked up and lost moisture rapidly (fig. 4). It began its major decline the first week of June and completed it by mid-August. The green-fuel moisture of black sage apparently follows closely the buildup and depletion of surface soil moisture. This type of response is reasonable because of the extremely shallow, spreading root system of the plant (Hellmers, _et al_. 1955). Black sage, like ceanothus, made a marked gain in moisture after the April 26 rain, reaching its highest moisture content for the year, 177 percent, by the third week of May.

Chamise green-fuel moisture content, on the other hand, followed most closely the trend of soil moisture at the 42-inch depth (fig. 5). Chamise is a deep-rooted species, penetrating to 25 feet

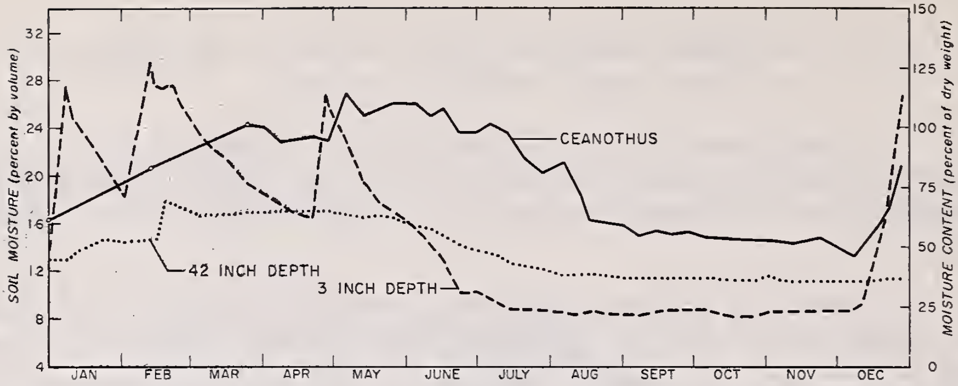

Figure 3.--Annual variation of soil moisture and moisture content of living ceanothus foliage and stems, 1959.

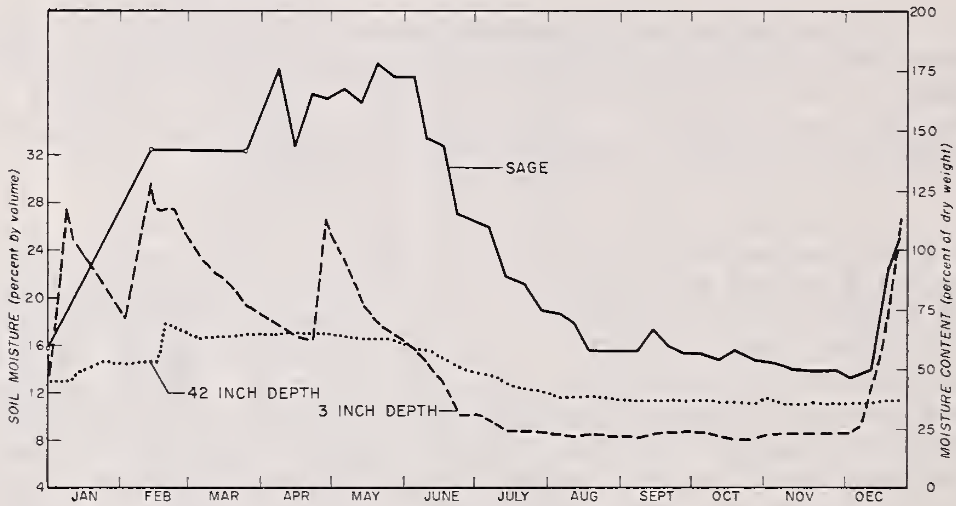

Figure 4.--Annual variation of soil moisture and moisture content of living black sage foliage and stems, 1959.

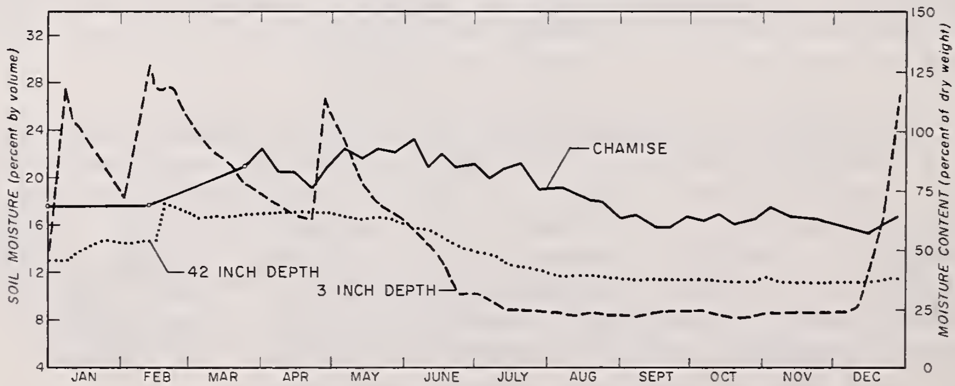

Figure 5.--Annual variation of soil moisture and moisture content of living chamise foliage and stems, 1959.

in unweathered rock (Hellmers, et al. 1955). It is the most tenacious of the three species and probably the most prevalent shrub in southern California.

In 1959 moisture content of chamise varied only slightly. Like the other two species, it gained moisture after the April rain, picking up 17 percent between late April and early May. The year's maximum, reached in early June, was 97 percent. Previous studies indicate that chamise normally reaches a seasonal peak of around 130 percent. Thus, chamise was a hazardous fuel the entire year.

Unlike ceanothus and black sage, chamise did not gain moisture appreciably after the December rains. Apparently new growth of chamise requires warmer weather than occurred at this elevation in December. Succulent new shoots were found on chamise in mid-December at 1,800 feet but not above 2,200 feet.

CONCLUSIONS

Major conclusions drawn from analysis of 1959 data are:

1. A good correlation between soil moisture and green-fuel moisture trends was revealed.

2. Short-term weather fluctuations had an appreciable effect on green-fuel moisture.

3. Studies of moisture content of green fuels must continue several years to obtain conclusive results relating fuel moisture to weather variables and soil moisture.

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